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Title: Pre-shot viewgraphs for first DT layered Beryllium Implosion

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# Pre-shot viewgraphs for first DT layered Beryllium Implosion

J. L. Kline June 18<sup>th</sup>, 2015



#### **Abstract**



This presentation contains details of the setup for the first Beryllium DT layered shot on NIF. This includes how the settings were derived using a combination of data from tuning experiments and pre-shot simulations. The presentation also contain details of the setup for key diagnostics.





**Shot Date: June 18, 2015** 

**Shot RI: Kline/Kyrala/Doeppner/Perry** 

Designer: Yi/Wilson/Simakov/Olson

### **Shot Summary**

### **Shot Purpose/Goals:**

Measure the performance of DT layered implosion on NIF using a beryllium capsule with high adiabat pulse similar to the first CH "high foot" layered implosions

### **Shot Description:**

 High foot, three shock pulse beryllium DT layered implosions with 1.45 MJ of laser. energy

### Brief summary of what is new:

First DT layered implosion with beryllium capsule



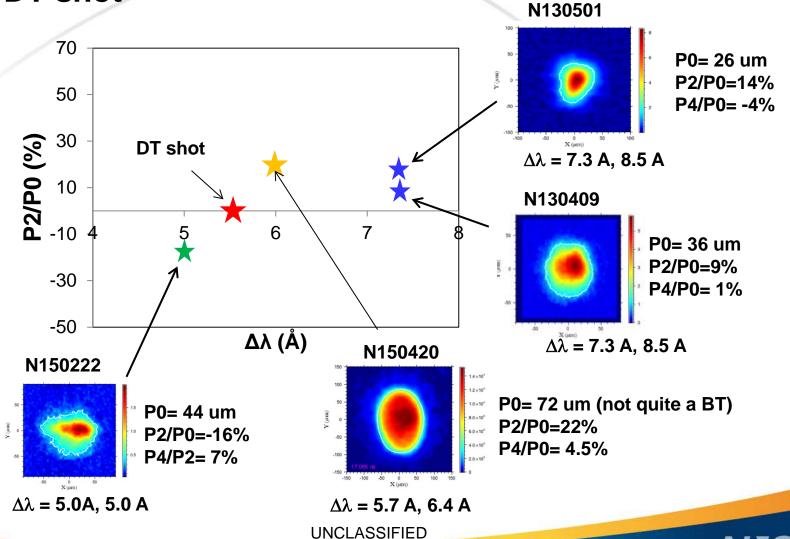
## Table of Changes from a Previous Similar Shot



	Previous Shot	Current Shot Name
	Shot Name: I_Be_2DCona_HF1	Shot Name: I_Be_2DCona_HF1
Pulse Shapes & Durations	Be_350TW_1DConA_150115_Inner (_Out) outers AP_1_ConA_bkl_120607BL's (Q26B, 31T)	Be_350TW_DT_150427_Outer outers Be_350TW_DT_150427_Inner inners
Total Energy & Energy/Beam	~1.4 MJ	~1.4 MJ
Peak Power	350 TW	350 TW
Amplifier Configuration	11-5 20%	11-5 20%
Delta Lambda	23(6.4),30(5.7)	23(5.9),30(5.2)
CPP Usage	Nominal 575	Nominal 575
Beam Pointing	Nominal 575 + backlighters (26B, 31T)	Nominal 575
Target & Fill Info (Taxon, description, materials, gas fill, fill pressure, temp & density)	ConA2D_Au_575.943_345_Be5.1_T_15- 100561 Au hohl. (1.6 mg/cc He4 fill 3.45 mm LEH)+Cu backlighter, Cu doped Be capsule (D-He3 2992 Torr) T=24K	THD_Au_575.943_345_Be55536_C_100581 Au hohl. (1.6 mg/cc He4 fill 3.46 mm LEH), Cu doped Be capsule (DT layer) T=19.5K;
DIM 0-0	RGXD4-HX-1200-14-12X-V2	RGXD4-HX-1200-14-12X-V2 + SRCs/NADs
DIM 90-78	HGXD2F HGXD4-H-540-12.7-6X+WRFs	HGXD4-HAD-1200-6.35-12X
DIM 90-315	N/A	NIS + SRCs/NADs
Other?	Dante, NToF, FABS/NBI	Rags

# Using the shape data from the 1DconA and the 2DconA, we can set the wavelength for the DT shot

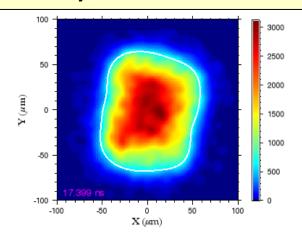




# Polar shape tuning used the CH experimental playbook to set $\Delta\lambda$ for 23 and 30 degree beams, but backed off some due to high transfer observed for Be capsules



# Measured Polar Shape from N150222 Beryllium 1D ConA shot

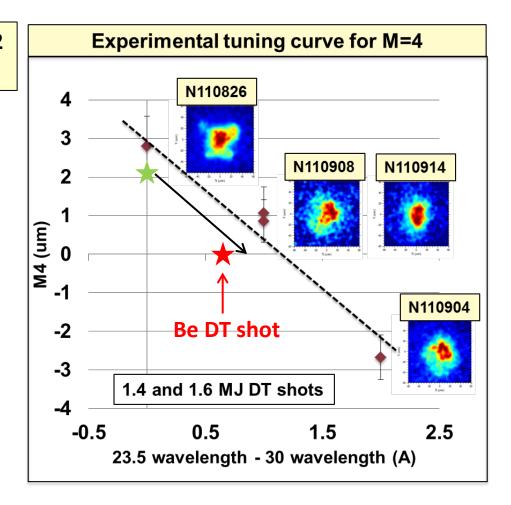


M0: 70± 8.4μm

M2/M0:  $(5.7 \pm 2.4)\%$ 

M3/M0:  $(3.7 \pm 2.5)\%$ 

M4/M0: (2.8 ± 2.5)%

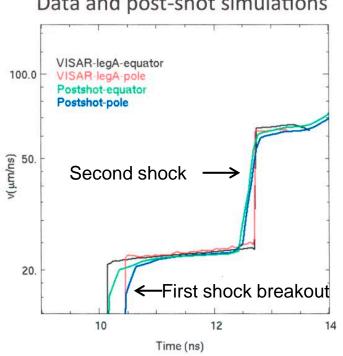


## Pulse is shock timed taking using the keyhole to calibrate the simulations



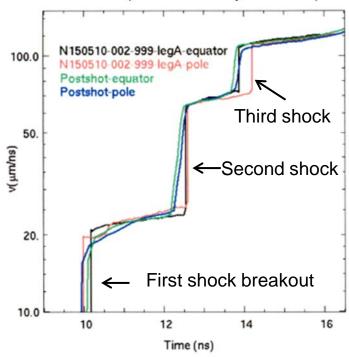
#### **Measured Polar Shape from N150325** Beryllium keyhole shot

#### Data and post-shot simulations



### **Measured Polar Shape from N150510** Beryllium keyhole shot

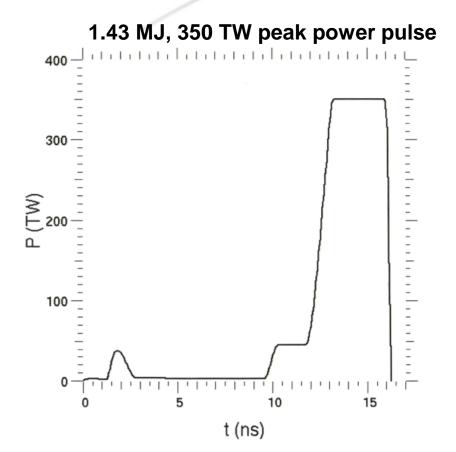
VISAR (data and synthetic)

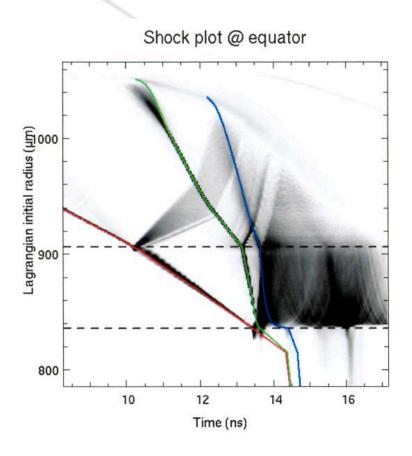


Because the VISAR data blanked after the second shot breakout on N150325, we lowered peak power to get the third shock data as they do for HDC shots

# Pulse is shock timed taking into account the as- Los A delivered picket energy from the previous 3 shots — ES







Laser delivered approximately 10% lower energy in the picket than requested in tuning shots N150325, N150420, and N150510

# Calculated Neutron Images for N150618 – Be DT capsule

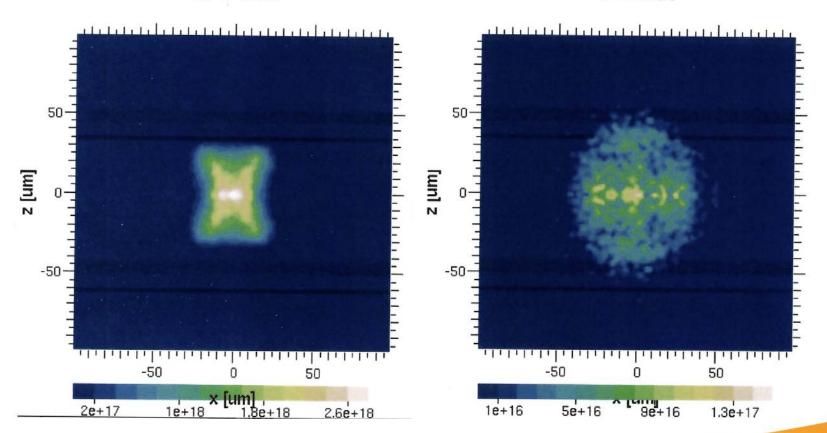




13-17 MeV

"Downscattered Image"

6-12 MeV





# **Key performance metrics:**



dsr = 0.039 (ρR [g cm <sup>-2</sup> ])	Simulations Expected value	N150618 Be, 1.43 MJ, scale 575, Be/Cu	N130501 High foot 1.35 MJ, scale 575, CH/Si	
Yield [50% DT]	1-2e15	7.87e14	7.71±0.18e14	
T <sub>i</sub> (keV) [ntof]	3.75	3.65	2.83±0.16	
dsr [MRS]	4.5%	2.86±0.33%	3.07±0.33%	
X Bangtime (ns)	17.6		16.8 ±0.012	
N Bangtime (ns)	17.6		16.7	
X-ray burn (ps)	80		225±12	
N burn (ps)[GRH]	100		198	
X-ray P <sub>0</sub> (µm)	26.5	31.9	26.4±1.8	
X-ray P <sub>2</sub> /P <sub>0</sub>	34%	159	0.15±0.035	
X-ray M <sub>0</sub> (µm)	26.5		38.9±0.5	
X-ray M <sub>4</sub> /M <sub>0</sub>			0.211±0.044	
NI P <sub>0</sub> (μm)				
NI P <sub>2</sub> /P <sub>0</sub>				



## Laser section

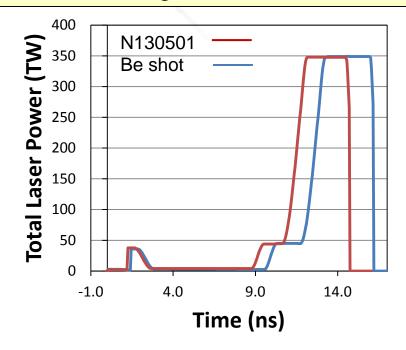


## The laser pulse shape is similar to the first high foot shot with a CH capsule



Laser Parameter	Value
1) Total per beam energy 8 kJ/beam	1.43 MJ 192 beams ~7.8 kJ/beam 11-5 @ 20%
2) Pulse length and shape	Slow rise, see separate viewgraph
3) SSD bandwidth, 3- color wavelength offset	45 GHz $\Delta \lambda_{30} = 5.2$ Å, $\Delta \lambda_{23.5} = 5.9$ Å
4) Beam focus/spot size, CPP usage	Rev1 Outer Cone 2w CPP Rev3 Outer Cone 2w CPP Rev1a Inner Cone 2w CPP Rev3 Inner Cone 2w CPP
5) Beam pointing	Scale 575 Hohlraum pointing * 23deg. z=±2.664mm, 30deg. z=±3.456mm, 44deg. z=±4.8965mm, 50deg. z=±4.7105mm
6) Beam delays	As specified in CMT
7) ADDS	96% rule

### Be Laser pulse shape compared with first High Foot CH shot



**Beam pointing:** Nominal 575, small LEH pointing



## **Laser Configuration:**



Laser Parameter	Value
1) Total per beam energy 8 kJ/beam	1.43 MJ 192 beams ~7.8 kJ/beam 11-5 @ 20%
2) Pulse length and shape	Slow rise, see separate viewgraph
3) SSD bandwidth, 3- color wavelength offset	45 GHz $\Delta \lambda_{30} = 5.2 \text{Å}, \Delta \lambda_{23.5} = 5.9 \text{Å}$
4) Beam focus/spot size, CPP usage	Rev1 Outer Cone 2w CPP Rev3 Outer Cone 2w CPP Rev1a Inner Cone 2w CPP Rev3 Inner Cone 2w CPP
5) Beam pointing	Scale 575 Hohlraum pointing * 23deg. z=±2.664mm, 30deg. z=±3.456mm, 44deg. z=±4.8965mm, 50deg. z=±4.7105mm
6) Beam delays	As specified in CMT
7) ADDS	96% rule

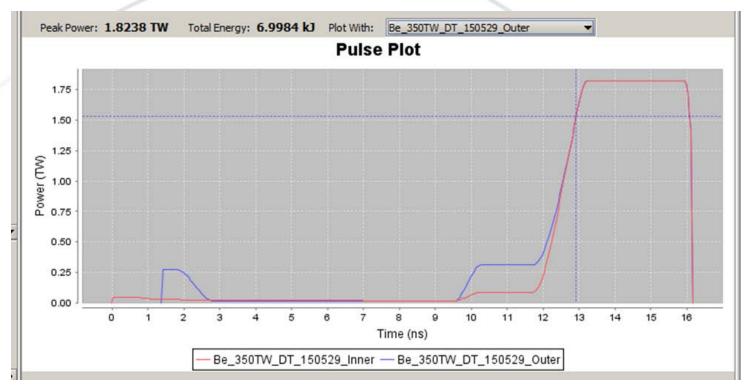
Beam selection TOP VIEW Q33T Q24B

**Beam pointing**: Nominal 575, small LEH pointing

\_\$IFIED

## Laser pulse shape definition





Delta Lambda: 5.2, 5.9 A Nominal 575 small LEH pointing Standard CPPs





# **Target section**



## **Target Definition**



Targets Parameter	Request
Hohlraum Mat.	Au
LEH size	3.459 mm
Capsule Thickness	160 um
Capsule dopant	0,0.4,1% Cu
Capsule Fill	DT
Capsule Fill Density	Layer
Hohlraum Fill	He
Hohlraum Fill Density	1.6 mg/cc
4Pi metrology	Yes

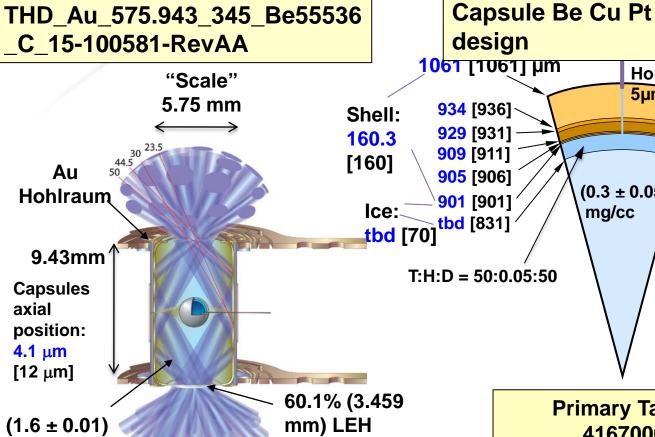


## **Target and Capsule definitions**





0% 1.82 g/cc 0.42% 1.87 g/cc 0.92% 1.93 g/cc 0.42% 1.86 g/cc 0% 1.81 g/cc Be + Cu



**Primary Target:** 41670001 Backup target: 41670002

Hole

5µm

 $(0.3 \pm 0.05)$ 

mg/cc

Mini-Quench

Capsules and Hohlraums are layered and fielded on cryo target positioner 90,15

mg/cc He

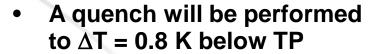
gas fill -

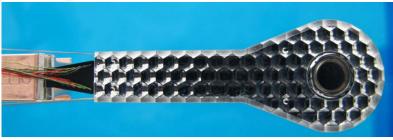
UNCLASSIF

### **Target 41670001 images**



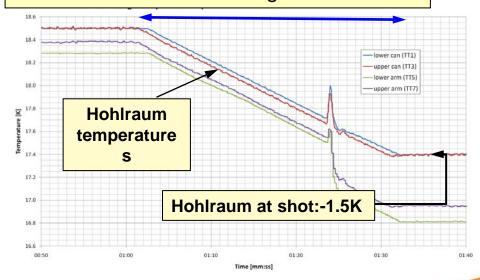
41670001 target TCC-120 mm cold shield extension







## 30 s THD quench target base controlled with cascade configuration





## **Summary of DT ice layer properties**

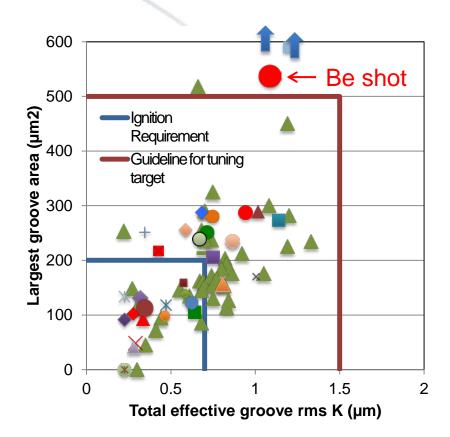


Executive summary							
	current layer (□m)	DT spec (□m)	Tuning spec (□m)				
Grooves							
К	0.58	0.7	1.5				
Biggest groove area in HighMag (µm^2)	139.5	200	500				
Biggest groove area in LowMag (µm^2)	136.2	200	500				
Side views, P and/or M i	modes. RMS per mode (squa	re root of power s	pectrum).				
P1	0.21	0.5	1.0				
P2	0.10	0.5	1.0				
P3	0.15	0.4	0.8				
P4	0.03	0.4	0.8				
LEH view, m modes. RM	S per mode (square root of	power spectrum).					
M1	0.39	0.5	1.0				
M2	0.08	0.5	1.0				
M3	0.02	0.4	0.8				
M4	0.01	0.4	0.8				
Roughness							
Average NIF factor "nfa"	0.16	1.0	1.0				
Layer thickness	Layer thickness						
thickness	69.1	69.0	69.0				

# The ice layer in terms of groove area is just outside the tuning specification of 500 um<sup>2</sup> derived for low adiabat implosions



- Specification for grooves from NIC
- High foot shots showed little sensitivity to groove shooting a shot with 1600 um^2 compared with a similar shot around 300 um^2 show the same nuclear performance
- Before shimming the ice layer to remove M1, the grooves were at 440 um^2.



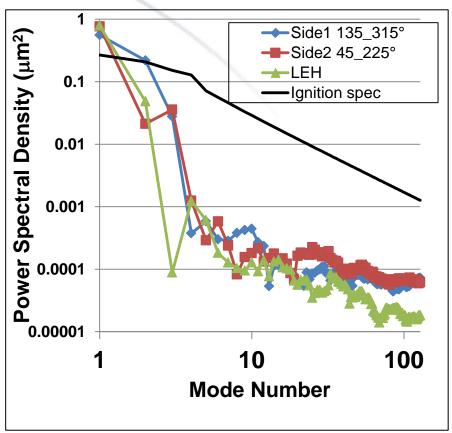
Based on the bullets above, the decision was made to keep the layer instead of risking not getting a layer for the first shot



## The low modes for the ice layer are just out of spec.



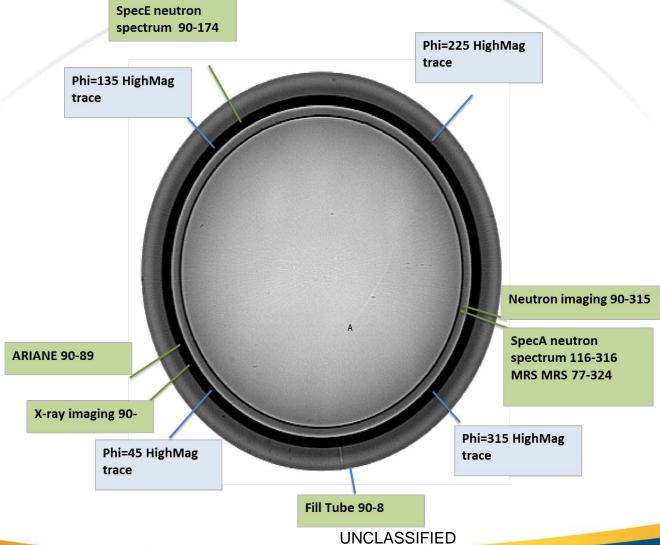
- To fix the low modes would have required changing targets because the limits of the shimming heater were reached.
- Backup target had not been proofed, so there was no guarantee that changing the target would have resulted in better ice layer.



Based on the bullets above, the decision was made to keep the layer instead of risking not getting a layer for the first shot

## Below is an image of the ice layer





## Mass Spec on DT fuel



Mass Spectrometry Analysis for Experiment					I_Be_DT_H	F1_S01			
	Analyst		Sanchez		& Reservoir Serial Numbers		06/12/2015; TPS		
NIF Target Gas Analysis	Witness Sample S/N; Fill Pressure	M	1506122015; 38 PS	IA					27800013
	<sup>3</sup> He Purge Time		6/12/15 8:31				PGAS173181		<u>27800014</u>
	Detector Used: Faraday Cup; Detection Limit is 0.006 mole % (60 ppm)								
Gas Components	Replicate 1 mole %	Replicate 2 mole %	Replicate 3 mole %	Average mole %	STDEV	% RSD	95% CL	Lower 95% CL	Upper 95% CL
H <sub>2</sub>	ND	ND	ND	NA	NA	NA	NA	NA	NA
³He	ND	ND	ND	NA	NA	NA	NA	NA	NA
HD	0.215	0.213	0.212	0.213	0.001	0.51	0.001	0.212	0.215
нт	0.197	0.190	0.191	0.193	0.003	1.72	0.004	0.189	0.196
D <sub>2</sub>	24.82	24.87	24.86	24.85	0.023	0.093	0.026	24.82	24.87
DT	49.20	49.20	49.21	49.20	0.009	0.019	0.011	49.19	49.21
T <sub>2</sub>	25.50	25.46	25.46	25.47	0.023	0.092	0.026	25.45	25.50
Total Atomic Components	Replicate 1 Atom %	Replicate 2 Atom %	Replicate 3 Atom %	Average Atom %	STDEV	% RSD	95% CL	Lower 95% CL	Upper 95% CL
Н	0.208	0.203	0.202	0.204	0.003	1.52	0.004	0.201	0.208
D	49.53	49.57	49.57	49.56	0.026	0.052	0.029	49.53	49.59
T	50.20	50.15	50.17	50.17	0.022	0.044	0.025	50.15	50.20

ND = Not Detected ≤ 60 ppm (except <sup>3</sup>He at ≤ 1000 ppm)

CL= Confidence Limit

NA= Not Applicable

RSD= Relative Standard Deviation



# **Diagnostic section**



# Diagnostic summary: Standard DT suite



A Comment of the Comm		
Diag	Locatio n	Priorit y
12x hGXI,-1 Ross Pairs	DIM 0-0	2
SCRs/NADS		2
12x hGXI-2, Ross Pairs	DIM 00 70	1
SCRs/NADS	DIM 90-78	2
		2
Dante 1	(143, 274)	2
SXI upper	(18, 124)	2
SXI lower	(161,326)	2
FFLEX	(90, 110)	2
EHXI	(90, 110)	2
DiXI	(90, 100)	2
FABs	Q31B, Q36B	2
NBI	Q31B, Q33B	2

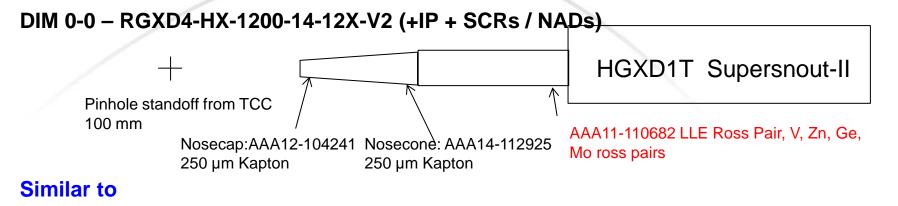
Diag	Location	Subs	Priorit y
	(64, 136)	4M BT setup for hots	2
		SpecSP	2
NTOF		20M IGNHI	2
	(64, 330)	4M DTHI	3
	(90, 174)	20M SPECE	2
	(116, 316)	20M SPECA	2
		Polar SPEC	2
NIS	(90, 315)		
MRS	(90-315)		
GRH	(64, 20)	64, 20)	
SPBT	(180,0)		2
SPIDER*		3	

Standard DT diagnostics with standard analysis

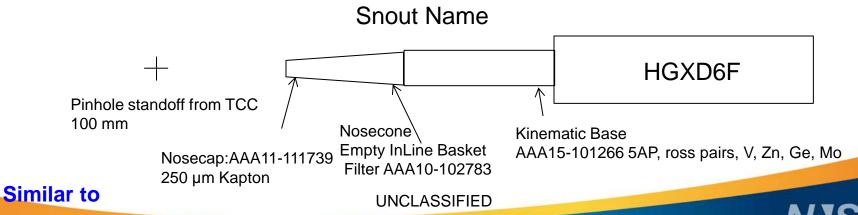
UNC

# DIM-based diagnostic configuration/filter details





#### DIM 90-78 - HGXD4-HAD-1200-6.35-12X (+IP+ SCRs / NADs)





## **Setup For Polar DIM**

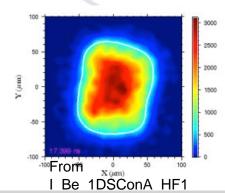


EST. 1943

#### **HGXD Location TC000-000**

Description			
Location	TC000-000		
Diagnostic	HGXD		
Priority	PRIMARY		
General Description	description		
Trigger Delta T (ns)	17.30		
Aim Point X (mm)	0		
Aim Point Y (mm)	0		
Aim Point Z (mm)	0		
Aimpint R (mm)	0.000		
Aim Point Phi (deg)	0.000		
Aim Point Theta (deg)	0.000		
Roll Angle (degs)	0		

Configuration				
Name	HGXD4-HX-1200-14-12X-V2			
Part Number	AAA11-110680			
Snout	HX-1200-14			
Cart Part Number	AAA12-105983			
Airbox Part Number	AAA12-105142			
Magnification	12X			
Aimpoint to Pinhole	100.0			
Pinhole to Detector	1200.0			
Aimpoint to Detector	1300.0			
Snout Tip to Pinhole	4.61			
Aimpoint to Snout	95.39			
Mirror Name	NONE			
Mirror Part Number	N/A			
Strip1 Ref Time	113.376			
Fidu Ref Time	-513.89			
Mon Fidu	648.9023			



	Assemblies				
Attribute	Nose Cap	Nose Cone	Kinematic Base		
Name	4 Zone 10um pinhole, 100um slit, W/Ta rear coll	2x125u Polyimide SSII In-Line Basket Filter	LLE SS2 1250um Poly,Vd/Zn/Ge/Mo/Poly, W5 SR IP		
Part Number	AAA12-104241	AAA14-112925	AAA11-110682		
Filter 1	4 Zone Collimator	125u 50x50 Polyimide Filters SS2	W5 1000um Polyimide		
Filter 1 P/N	5037335	5038114	AAA11-114068		
Filter 2	125u 14mm Dia. Polyimide	125u 50x50 Polyimide Filters SS2	W1-W3-W7-W9 250um Polyimide		
Filter 2 P/N	5040459	5038114	AAA11-114066		
Filter 3	125u 14mm Dia. Polyimide	NONE	Vd/Zn/Ge/Mo/Poly		
Filter 3 P/N	5040459	N/A	AAA11-114072		
Filter 4	4 Zone Pinhole	NONE	25um Aluminized Polyimide		
Filter 4 P/N	5037334	N/A	AAA11-114073		
Filter 5	4 Zone W/Ta Rear Collimator	NONE	W5 Aperture SR IP		
Filter 5 P/N	AAA12-105123	N/A	AAA11-114074		
Filter 6	NONE	NONE	NONE		
Filter 6 P/N	N/A	N/A	N/A		
Filter 7	NONE	NONE	NONE		
Filter 7 P/N	N/A	N/A	N/A		
Filter 8	NONE	NONE	NONE		
Filter 8 P/N	N/A	N/A	N/A		
Filter 9	NONE	NONE	NONE		
Filter 9 P/N	N/A	N/A	N/A		
Filter 10	NONE	NONE	NONE		
Filter 10 P/N	N/A	N/A	N/A		



# DIM 00-00 setting (2 strip GXD)

### From Approval Manager

2015

**DIM 00-00:** RGXD4-HX-1200-14-12X-V2

**Comparison shot is N150222** 

Bias = 60

Max counts =  $^{\sim}3000$ 

Using same instrument, expect 4-12x more signal

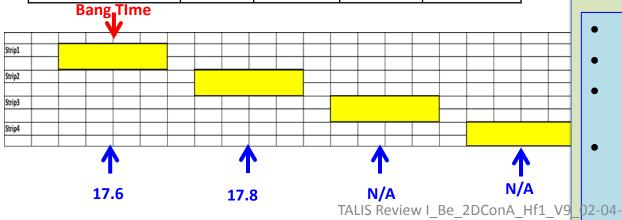
=→ 60v change to 150 Volt is 3^2=9 x

**Expected BT = 17.6-17.7 ns** 

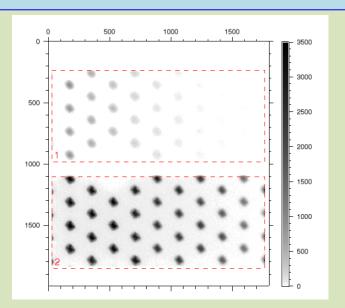
4/2/15

**Additional Delay** Client delay = 17.6 ns

GGXD	HGXD1T 2 strip vertical 100 ps			
Number of Strips	2			
Attributes	Strip 1	Strip 2	Strip 3	Strip 4
Timing Delay	0	250		
Backbias (V)	150	150		



#### **HGXD N150222**



- Magnification 11.9X
- 50 V MCP.
- Peak CCD signal was 3000 counts, 100-200 counts above background.
- strip delays 0/200/400/600/ ps.



## Setup For 90-78 DIM

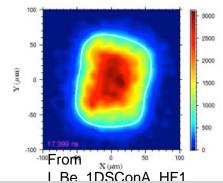


EST.1943

#### **HGXD Location TC090-078**

Description			
Location	TC090-078		
Diagnostic	HGXD		
Priority	SECONDARY		
General Description	description		
Trigger Delta T (ns)	17.20		
Aim Point X (mm)	0		
Aim Point Y (mm)	0		
Aim Point Z (mm)	0		
Aimpint R (mm)	0.000		
Aim Point Phi (deg)	0.000		
Aim Point Theta (deg)	0.000		
Roll Angle (degs)	0		

Cor	Configuration			
Name	HGXD4-HAD-1200-6.35-12X			
Part Number	AAA12-118327			
Snout	HAD-1200-6.35			
Cart Part Number	AAA12-105982			
Airbox Part Number	AAA12-105142			
Magnification	12X			
Aimpoint to Pinhole	100.0			
Pinhole to Detector	1200.0			
Aimpoint to Detector	1300.0			
Snout Tip to Pinhole	5.32			
Aimpoint to Snout	94.68			
Mirror Name	NONE			
Mirror Part Number	N/A			
Strip1 Ref Time	26.907			
Fidu Ref Time	-529.347			
Mon Fidu	577.7903			



	Assemblies				
Attribute	Nose Cap	Nose Cone	Kinematic Base		
Name	186 Hole 6.35ID PH/Coll Kit 250um Polyimide, Type 2	Empty InLine Basket Filter	Filter, 5AP,2mm,Al Out Ge/Mo/V/Cu/Ag/Poly34x34IP		
Part Number	AAA11-111739	AAA10-102783	AAA15-101266		
Filter 1	186 Hole 150um Dia 500um Thk Ta Coll	NONE	5 AP filter w/2mm poly center AP		
Filter 1 P/N	AAA10-101429-03	N/A	AAA13-104979		
Filter 2	125u Thk Polyimide Filter	NONE	Filter, 5 AP, 80um AI on outside		
Filter 2 P/N	AAA10-115166-125	N/A	AAA13-111606		
Filter 3	186 Hole 10um Dia 75um Thk Ta PH	NONE	Filter 5AP, AI, Ge/ Mo/V/ Cu/Ag		
Filter 3 P/N	AAA10-101429-01	N/A	AAA13-111607		
Filter 4	125u Thk Polyimide Filter	NONE	Filter, 5 AP, 250um Polyimide		
Filter 4 P/N	AAA10-115166-125	N/A	AAA13-104623		
Filter 5	186 Hole 150um Dia 500um Thk Ta Coll	NONE	25um Full size Al Polyimide		
Filter 5 P/N	AAA10-101429-03	N/A	AAA09-119831		
Filter 6	NONE	NONE	34x34 Aperture Image Plate		
Filter 6 P/N	N/A	N/A	AAA09-118138		
Filter 7	NONE	NONE	NONE		
Filter 7 P/N	N/A	N/A	N/A		
Filter 8	NONE	NONE	NONE		
Filter 8 P/N	N/A	N/A	N/A		
Filter 9	NONE	NONE	NONE		
Filter 9 P/N	N/A	N/A	N/A		
Filter 10	NONE	NONE	NONE		
Filter 10 P/N	N/A	N/A	N/A		



# DIM 90-78 setting (4 strip HGXD2)

**DIM 90-78:** HGXD4-HAD-1200-6.35-12X

Comparison shot is N150222

Bias Was= 60

Max counts = 3000

Instrument 2x more sensitive, expect 4-12x more signal, 500

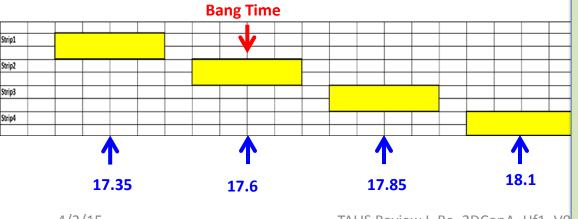
um more polyimide

We need more gain =→ 150 V

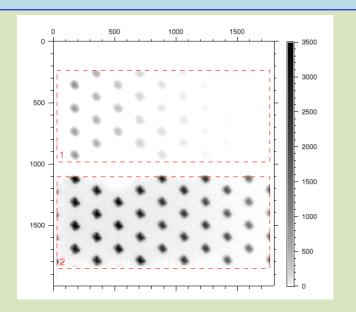
**Expected BT = 17.6-17.7 ns** 

Client delay Additional Delay= 17.35 ns

HGXD	HGXD6F	HGXD6F 4 strip horiz 100 ps			
Number of Strips	4				
Attributes	Strip 1	Strip 2	Strip 3	Strip 4	
Timing Delay(ps)	0	250	500	750	
Backbias (V)	150	150	150	150	



#### **HGXD N150222**



- Magnification 11.9X
- 50 V MCP.
- Peak CCD signal was 3000 counts,
   100-200 counts above background.
- strip delays 0/200/400/600/ ps.

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## **Setup For DIXI**





# DIM 90-78 DIXI setting (4 strip)

**DIM 90-78:** HGXD4-HAD-1200-6.35-12X

**Comparison shot is N150222** 

Bias Was= 60

Max counts = 3000

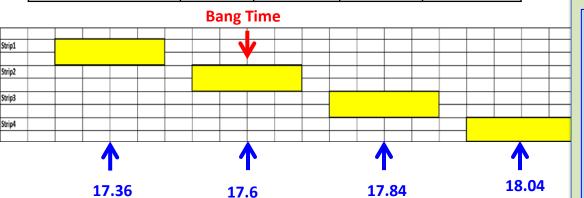
expect 4x-12x more signal

We need more gain =→

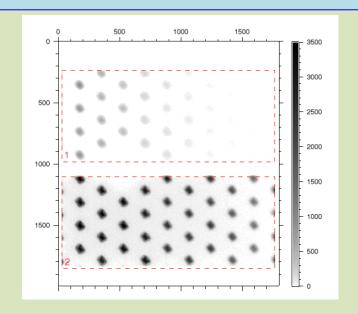
**Client delay Additional Delay= 17.6 ns** 

**Expected BT = 17.6-017.7 ns** 

DIXI	Dixi 4 strip horiz 100 ps			
Number of Strips	4			
Attributes	Strip 1	Strip 2	Strip 3	Strip 4
Timing Delay(ps)	-240	0	240	480
Backbias (V)	-50	-50	-50	-50



#### **HGXD N150222**



- Magnification 11.9X
- 50 V MCP.
- Peak CCD signal was 3000 counts, 100-200 counts above background.
- strip delays 0/200/400/600/ ps.

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